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Culture – educational paradigm shift learning methodologies derived from axiomatic design principle

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Abstract

Teacher-centered learning pedagogy is a passive approach but most standard practices in many engineering courses than the active approach that is student-centered learning pedagogy. For a country like Papua New Guinea which is rich in culture diversity, the social structure or group identity forms the lines of conflict affecting teacher or student-centered approach. With the advent of technological tools to support teachers in engaging student, the choices are too many to explore. Consequently, the confusion to which learning methods and technical tools are appropriate to the student that have culture affiliation and use such affiliation in engaging them in higher order thinking, knowledge integration and self-efficacy requires support to get the right instructional methodologies based on the Axiomatic design (AD) principle. The results show that the combination of AD law simplifies what learning design for engineers can create a paradigm shift in culture to educational synergy.

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1. Introduction

2. Paradigm shift according to Thomas Kuhn is a change in the underlying assumption of worldview or a profound shift in a fundamental model of events [1]. Centuries ago, the method of teaching had not change a lot. The use of blackboards which later turn into whiteboards and smartboards were the tools used to convey knowledge to the student. However, in this generation, such activity is quite boring to many students.

Nomenclature

AD	axiomatic design
CN	customer needs
DP	design parameter
FR	functional requirement
PV	process variable
PNG	Papua New Guinea

In most cases, lecturers find student sleeping if not; they do not mind their classes. Incorporating laboratory activities provided a good diversion to classroom boredom and enhancing information delivery as a student are engaged.

In the case of Papua New Guinea University of Technology students, each student represents the diverse cultural groups. About 800 different cultures in the country share the same values, beliefs, attitudes, preferences, customs, learning styles, communication styles, history; historical interpretations, achievements; accomplishments, technology, the arts, literature, etc. [2]. Most of these students are first from the tribes or of the family, and the government sponsors most of their school fees. Tribal war happens in the university whenever cultural issues occur which affects student learning as shown in Fig. 1. A photo of a first year students who were beaten by other students due to a tribal war in campus and had received black eye and arm cuts.

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Fig. 1. (a) Result of campus fight (posted with permission); (b) Tribal identity.

According to Schram [3], the Vice Chancellor of Papua New Guinea University of Technology, in 2011 before he arrived there had been a huge fight between two groups of students along tribal lines, which one student died. The next year the tension between the rival tribes increased that the campus security officers had to fire their gun into the air to stop an all-out battle that ended with a traditional reconciliation dance resolved thru dialogue. The Papua New Guinea (PNG) culture is rich and with high identity in each tribal group because 97 percent of the country's land are customary. Due to this identity, tribal conflict is frequent because of the rationalization that fighting is a morally acceptable norm.

Creative energy and unproductive conflict may result from cultural diversity within small groups [4]. The migration creates diversity as they carry their languages and customs with them and re-create their existing social structures [5, 6]. Their ways of life as played in the villages takes part into the classroom. They also have a strong family tie, wantok system, which a wealthy family member should share their wealth with other family members who are less privileged. Even those who are artisan should source job for other family members [4, 6]. The social bonds and obligations of the wantok system are often held to be a cause of corruption. However, if the creative energy is harnessed, the unproductive conflict will be minimized if not eliminated.

The study of Betasolo [5] shows that student taking Engineering Materials and Engineering Mechanics (both Engineering subjects) are not interested to be lectured, nor directed by lecturers. Students wanted to prepare for the job, yet they don't want to develop higher order thinking skills, nor foster development and personal growth, and with no interests to develop basic learning skills. Furthermore, the assessments show an interesting revelation that students wanted to understand real life situation yet, the core competencies to do it is not supported. With the advent of technological advancement, engaging student is not a problem in other countries, but to Papua New Guinea's tertiary or university student, the use of these technologies is their first, and the fear of the utilization of these technologies is a hindrance

Betasolo [5] stressed that to get student's participation and the teaching approach should be student centered. An Inductive Technique Instruction (ITI) is a much more student-centred approach using a strategy known as ‘noticing,' where a concept is presented with many examples showing how the concept is used to let the students "notice," how the idea works. The inductive teaching philosophy allows learners to discover and experience phenomenon to achieve learning on their own. When the author started the first semester in 2013 at the Department of Civil Engineering of the Papua New Guinea University of Technology located in Lae of Morobe Province, the laboratory works were conducted in a demonstration only and without engaging the students. So when the author introduced the ‘noticing' concepts where students can build their learning they take a time to assimilate. It is where the culture-educational paradigm shift learning concept was conceived.

Among the strategies used in ITI are inquiry learning, problem-based learning, project-based learning, discovery learning, cased-based teaching and just-in-time teaching. The approach imposed more responsibility for student learning. The student learns by fitting new information into existing cognitive structures and is unlikely to know if the information has few apparent connections to their understanding and believe. This approach is a constructivist method. The principle of this approach is that student constructs their version of reality rather than simply absorbing lessons presented by lecturers. The method almost always involves student discussing the question and solving problems in class (active learning). The teacher's approach is not to directly supply information. Thus, the students are given more avenues to think about what they have observed and experienced developing independent thinking, and higher order thinking skills to achieve an authentic learning.

The methods presented were first approached in the traditional way (after the 2014 study). In the advent of the technology advancement, the integration of the technology was thought to be challenging. It is because of some constraints like access to the technology freely and the continuous support to use the technology. The most challenging task in the selection is the best teaching and learning a methodology that is appropriate to the skills required by an employer of today's modern society. It is an educational challenge to bring the graduate engineers to the expected level because the learners have a hesitancy to adopt new pedagogical concepts introduced due to evolving economy and that they are not familiar with, that maybe the concept is in conflict with their experience. The challenge is addressed by the Axiomatic Design approach discussed below.

2. The AD Approach in CEPSL Methodology-Technology Integration Selection

Technologies are a tool to aid education and learning. It promotes student-centred learning, allows interaction together, gather information using the internet, enhanced critical thinking, it hone communication skill, allow sharing of ideas without boundaries, and it provides opportunities in designing creativity. The technologies are not the process nor are they the work. But technologies help to achieve the objectives in easier and more efficient manner. The key aspect of axiomatic design (AD) is the separation between what a system has to meet (functional requirements) and the design choices involved in

how to achieve it (design parameters) as shown in Fig. 2, modeled after that of Suh [7].

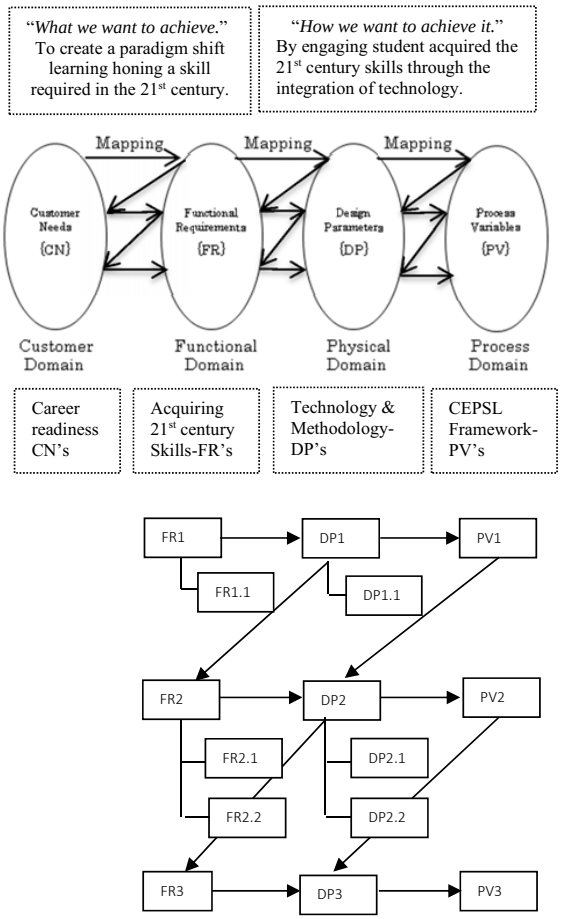

Fig. 2. Decomposition of FRs, DPs & PVs in the AD process[5]

Engineering graduates require an ever-increasing range of skills to maintain relevance with the global environment of the new millennium. Career readiness in a modern knowledge-based economy requires most not the mastery of a given piece of knowledge, but the capacity to assimilate new data and to solve real problems as they arise [8], it is what the customer needs (CN's) for the engineers of the 21st century.

The functional requirement (FR's) is mapped from CN's that provides practical 21st-century skills for engineers. It should chart design parameters (DP's) of technologies that support the development of the 21st-century skills (21cs). It is also mapped from the FR's that will help the student acquire those skills that are adept to the changing environment. In the same manner, the Process Variables (PV's) is also mapped from DP's. The mapping helps maintain the independence of FR to DP and DP to PV, as illustrated in Table 3.

Table 1 shows the 21st-century skills for engineers that are needed to be honed to be technically competent in their chosen field as well as well equipped with the complementary life skills. Such as problem-solving, reflective and critical thinking, interpersonal and teaming (collaborative) skills, active communication, character, integrity and self-esteem, self-discipline, organizing skills and abilities to translate ideas into action [9].

To achieve the goal of 21st-century skills development is best supported with the technology integration using Learning Management System (LMS). It is a framework that handles all aspects of the learning process such as content, identifies and assess individual's learning, track student's progress, collects and presents data for supervising the learning process. It is used to enhance and support classroom teaching and efficiency courses to a larger population of learners. It delivers the course content efficiently.

The availability of LMS is so many in the market which creates confusion which one is best for use in the classroom. To mention a few that the author had explored are Moodle, Blackboard, Schoology, ELMSLM, NEO LMS, and Google Classroom. Moodle is free but will require internal tech resources and needs maintenance for viruses. Blackboard is free, but some functionality is not available if not paid. Schoology is free and suitable for educators, but some functions need to be upgraded and will require payment. ELMSLM is free but has a steep learning path. NEO LMS has limited free version. Google classroom, on the other hand, is, widely used by many (already users of Gmail) since Google builds it, the Google Classroom is compatible with Google Drive, and other Google Apps. It has an ability to allow students to make a comment and to post in the classroom thus, encourages student participation. Google classroom also creates an individual class and permits the student to self-enrollment. The system is exclusive to the institution and provides flexibility to teachers just like in a traditional classroom that the teacher can bring learning resources to the classroom. It minimizes so much printing (paperless) that also helps the university to save on printing (papers, toners, electricity, etc.).

Table 1. Culture-educational paradigm shifts learning design matrix

	DPs	*CEPSL Model*	*Institu-tional*	*Project-based/case-based/problem-based*	*Inquiry/ discovery learning*	*Per-sonal*	*Group Discussion*	*Debate*	*Instruct-ional*	*Labora-tory*
	FRs	DP0	DP1	DP1.1	DP1.2	DP2	DP2.1	DP2.2	DP3	DP3.1	DP3
FR0	Acquiring 21st Century Skills (Engineers)	**x**	0	0	0	0	0	0	0	0	0
FR1	FR1: Provide avenue to hone Educational Values		**x**	0	0	0	0	0	0	0	0
FR1.1	Develop higher order thinking skill		0	**x**	0	0	0	0	0	0	0
FR1.2	Hone Critical Thinking skill		0	0	**x**	0	0	0	0	0	0
FR2	Enhance Diversity & Cultural Values		0	0	0	x	0	0	0	0	0
FR2.1	Advanced Collaboration and teamwork		0	0	0	0	x	0	0	0	0
FR2.2	Foster cooperative learning		0	0	0	0	0	x	0	0	0
FR3	Provide adequate Course Content		0	0	0	0	0	0	x	0	0
FR3.1	Provide opportunity for real work		0	0	0	0	0	0	0	**x**	0
FR3.2	To achieve knowledge base		0	0	0	0	0	0	0	0	x

The choice of an LMS was based on the AD process is presented in Table 2.

Table 2. Axiomatic Design on LMS selection.

Functional Requirement (FR's)	Design Parameters (DP's)
FR0: LMS Capability	DP0: Supporting Classroom Environment
FR1: Easy to use and accessible for all devices:	DP1: Student control
FR2. Effective communication and sharing	DP2. Student support
FR3.Speeds up assignment process	DP3. System performance
FR4. Effective Feedback	DP4. Self-evaluation
FR5. No need for paper	DP5Quality performance
FR6: Clean and user friendly interface	DP6: Explicit criterion
FR7. Great commenting system	DP7. Engaging Platform
FR8. Is for everyone	DP8. Self-regulation

Table 2 reflects on service performance of the learning management system (LMS). The integration of the curriculum and technologies answers three (3) broad domains of competencies such as cognitive, intrapersonal and interpersonal. The activity will deepen students learning. An LMS also promotes diversity, expand enrollment, and access to world-class research. In this age of globalization, international projects are increasing, and cross-cultural communication and collaboration are rising, especially that in the international practice of engineering a modern engineer must also be able to communicate effectively in a shared tongue. It is of this importance that engineering projects are now planned and implemented across national and cultural borders that will require teamwork and collaborative abilities necessary in the profile of the engineer and scientist in this current emerging world order that has become pro-soft-skills [10].

2.1 CEPSL Model

The cultural-educational paradigm shifts learning (CEPSL) model is presented here to embodied the influence of the technology in preparing students to enter the 21st-century workforce that maintains PNG's rich culture. And educationally equipped with skills that will lead to developing the country's natural richness and the inclusiveness of a knowledge base society leading to provide key players in the developmental strategy of a fast changing society of Papua New Guinea.

The model incorporates the Culture-Educational Paradigm Shift Framework of three (3) major components: Cultural-Values, Educational-Values, and Course-Content [5]. The Cultural Values are best to achieve by incorporating the

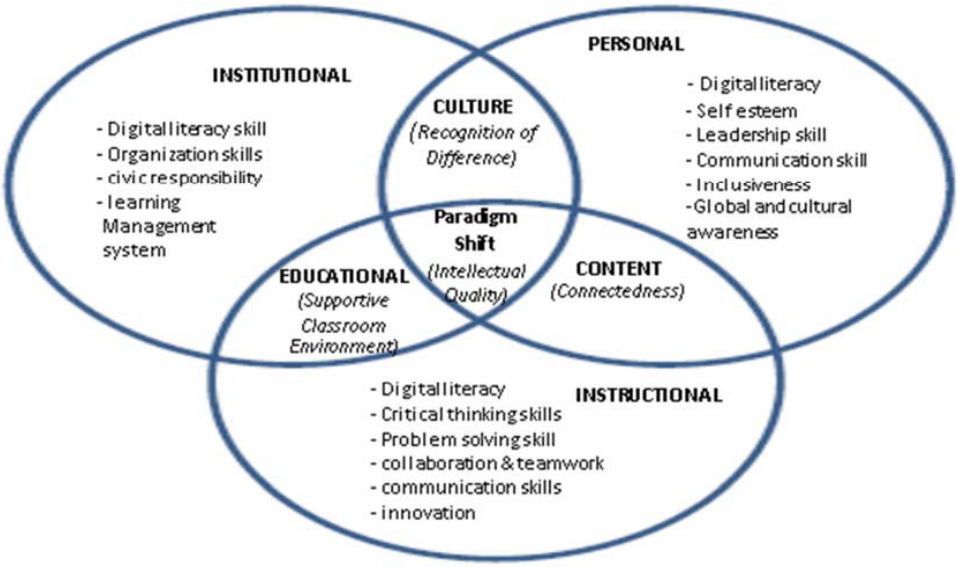

Fig. 3. Cultural-educational paradigm shift learning (CEPSL) model

responsive classroom approach RCA) where students' social and emotional growth places into their academic learning, stemming from the notion that student learns best through social interaction. The author integrated the approach because the study shows that it increases the school achievement of students, it decreases problem behaviors, improves social skills, and raise the quality of instruction [11]. Therefore, the author's integration of RCA into the CEPSL aims to minimize the disinterests to adapt to changes in the classroom modernization. For an Engineering subjects, conducting laboratory activities alone is not sufficient to gain the required technical capability that an engineer should possess. A course content enhancement should be in place to prepare the engineer solves real problems that are affecting human existence. On the other hand, memorization of facts and procedures is also not enough to succeed in the knowledge-based economy. Which will require an educated worker to understand conceptually a complex concept, the ability to work innovatively, critically evaluate what they read and stress points in writing and orally, and a deep understanding of mathematical and scientific thinking [12].

But, for Papua New Guinea engineering students, there is a cultural barrier that hinders the full implementation of acquiring knowledge-base to equip the student to face the different scenarios. According to Betasolo's [5] study that adding more content to the subject shows a low performance of students when the higher order of thinking (analyzing, evaluating, and creating) in Bloom's taxonomy [13] is applied. Then, the author also integrates the Culturally Responsive Pedagogy (CRP), which is a student-centered approach to teaching. The method identified the students' unique cultural strengths that promote student achievement and cultural pride of who they are and what the world sees them make sense of student's well-being [14]. The functionality of CRP in three dimensions: the institutional, the personal, and the instructional dimension are waived into the cultural, educational, and content concentration as discussed below.

2.2 Result & Discussion - Instructional Methodologies for Student-Centered Approach in CEPSL

The instructional methodology adopted in most engineering classroom is a teacher-centered approach which includes instruction by the teacher to present the information that is to be learned and to direct the student learning process. It is the teacher that identifies the lesson objectives and takes the primary responsibility for guiding the instruction by an explanation of the information and modeling. Methods that fall into the teacher-centered approaches include demonstration, direct instruction, lecture, and lecture-discussions.

Today, the lecture is the most criticized of all teaching methods because it puts students in a passive role and research has shown that after 10 to 20 minutes of continuous talk, the assimilation falls off rapidly [11]. The author's experience in lecturing for 17 years now tells the truth of the matter that student's attention is limited in this generation. If the author prefers lecturing, these techniques must enhance learner retention by active learning. Active learning is grounded in constructivism, learner-centered approaches where the teacher acts as a facilitator (or guide) as the students construct their understandings. Among the list of activities for an active learning are case studies, cooperative learning, group discussions, discovery learning/ inquiry-based learning, scaffolding, problem-based learning and, simulation, multimedia stories and examination.

Among the listed learning strategies, those that the author used in implementing the CEPSL model are listed in Table 3.

Table 3. Summary of CEPSL Pedagogy and career readiness path.

Instructional Methodology	21st century skills
Project-based/Case-based/problem-based learning	Innovation
Inquiry/discovery & scaffolding learning	Critical thinking
Group Discussion	Communication
Cooperative learning,	Collaboration and teamwork
Simulation, and	Digital literacy, and
Examination	Problem solving

A project-based learning is an instructional approach to learning that engages student interests and motivation. The activities for this type of learning are designed to answer a question or solve a problem that reflects the learner – working people do in every day in the real world [13]. A project-based learning starts with a task of one or more that lead to the production of a final product as a design, a model, or a device. The culmination of the project is normally a written and/or an oral report that summarizes the methods used to produce the product and presenting the outcome. Project-based learning is similar to problem-based learning in several respects. Both frequently involve a group of students answering challenges that are similar to what professional's do, where they have to formulate a solution to the challenges or strategies and to re-evaluate their approach in response to outcomes of their efforts [14]. A problem that the student will do in a project-based Engineering Material class is embodied in a theme: Concrete Innovation. To illustrate further, the author together with the students make a project on innovating concrete where they use milk cartoon (paper) [15] as an ingredient for concrete. Another innovation is the use of Rabaul volcanic ash (RVA) [16] a modified methodology from the previous project as an innovative component to concrete mix [17] is shown in figure 4a and 4b respectively.

Some second-year student says as a result of the exercise,

"I did more research on concrete innovation, and I understand the theme well. Indeed, it was a broad topic, but we refined to specific sub-topic. It helped me to develop skills in research, comprehend and analyze. Project task gives to students enable them to become self-learners. They would need more literature and understand the topic very well."- Abel Moke.

Fig. 4. (a) Students are preparing the milk cartoons (paper only) as ingredients in concrete mix; (b) students showing the cement cubes from RVA

"From my experience in the project, we have learned much when we carry out the lab test and doing so, but at first, I could not understand what to do on the project. However, as we go along doing the project, I easily know what to do in the project. The material we used for concrete is a plastic bag as fine aggregate. Therefore, the project that we are doing is just a sample but the real is yet to be conducted and be done during my final year."- James Salo.

A problem-based learning & inquiry involves the lecturer giving the student a problem where inquiry must be utilized to solve the problem. It involves four steps: 1) receives or create the problem, 2) gathers data, 3) organizes data and attempts an explanation to the solution of the problem, and 4) Analyze the strategies they used to solve the problem. A case study, on the one hand, involves groups of students that are working together to investigate a "case" that has been written about but will require a solution to the problem. The method allows students to apply new knowledge and skills for solving complex issues.

An inquiry learning process is based on asking questions of different factors such as difficult level of questions, the framework and the context for questions. The process will develop students to think critically and adapt to the different situation by looking at the pros and cons of it. The author's stay for three (3) years in Unitech (PNGUOT) and observing the way people communicate, a forum or debate is being part of the culture. The author seat as a judge in a conducted student debate during an Open Day in 2015 and found that students assimilate to this better. On how to use a debate in an Engineering Material class is somewhat absurd but I make a try. The debate was conducted on the issues: 1) Are concrete innovation technologies helping create a sustainable environment? And, 2) are continuous innovation, research and developments in concrete are essential in the construction industry sector? As shown in Fig. 5

Feedback from some students on the conduct of a debate says,

"Debating is good because it encourages us to do more research for presenting reasonable points. So overall, debating is good because it helps us learn." – Samson Kana.

Fig. 5. (a) Debating team in Concrete Innovation; (b) Postgraduate international student from the Department of Civil Engineering, The Director of Teaching and Learning Method Unit (TLMU), and A final year Student posed as judges in the debate

"During the debate, I come to experience some of my weakness (like I was not fit to talk in the public confidently). Also, the debate leads to me know some good and bad side of the innovating concrete. To my experience in a debate, I suggest having more debate in learning programs."- Dicky Rimbao.

Discovery learning has the same method as an inquiry-based learning where learners use their experience and prior knowledge to discover new information to construct learning. Inquiry-based learning is based on the strategies that student practice problem-solving and critical thinking skills to arrive at a conclusion. This teaching method is extremely student-cantered and student-directed, and can be modified for students at any level, reaching them where they are. Lecturer need to start by modeling the process to the students [13]. The Scaffolding methods involve the skill and thinking by the lecturers. As the student increases understanding, the assistance is withdrawn allowing the student to take on more responsibility for the learning.

Group discussion method is designed to encourage thinking skills and allow learners to increase interpersonal skills. Traditionally it is conducted in the classroom and modernly in online. One way to implement a discussion with twenty-first-century students is to use discussion boards known as "Google Groups or in the Google Classroom." These areas are places where the teacher and students can post a question on a "threads" or comments to the question asynchronously. Discussion boards vary in participation. An incentive (extra marks) is practiced to motivate all student participation. Group discussion triggers effective ways to present a collective experience as participants' engagement with the content and each other.

According to some students, "Participating in the discussion forum in Google classroom helped us to be analytic on issues relating to innovation in concrete, and it promoted us to do further research based on the topic discussed. As a result were able to find and gain new valuable information/knowledge about concrete technology"- McGregor Yangu.

"I found out that people have different ideas or points on the same topic or issue. In the discussion forum, I have seen that, and I make my adjustment and learn much on the discussion forum with this experience I recommend that discussion forum is good for learning or teaching."- Dicky Rimbao.

The cooperative learning involves small heterogeneous student groups that are working together to solve a problem. All students in the group maintain some independence. The success of the group depends on the input of each. The teaching method promotes active participation, individual accountability, students' ability to work cooperatively and improvement of social skills.

Simulations are activities in a "real" situation without taking the risks. Simulations are meant to be as realistic as possible where students can experience consequences of their behavior and decisions. Computer simulations are quite common in today's virtual world. An example of simulation we do in the university is the simulation of laminar and turbulent flow, also current flowing in a channel at our hydraulics laboratory.

An examination is an assessment of students understanding to the knowledge-based which is scheduled or unscheduled to stimulate learners to study. Evaluation methodology can be a completion of project study. A true-false and multiple choice force memorization of facts and statements. Short and long answers examination forces an overall general concept of the material are components in an online and in-class quiz.

Impressions on quiz are as follows:

Samson Kana says, "Quizzes is a very effective way for a student to understand theories and concepts of innovating concrete. Because when there is a quiz to be done, I stayed up late studying and found out that I learn many new things myself from reading, so it's good, the quiz is effective."

Abel Moke further says, "The three quizzes which I did so far on the theme were a bit tricky. It enables us to develop skills in analyzing and understanding the question very well before you answer. I did not score good marks on the quiz, but I realized my mistakes. It will help me preparing for my final exam. I observed that the quiz you made was all based on what we learned in the classroom. It all depends on the individual student to study hard and get good marks."

3. Conclusion & Recommendation

One can quickly become overwhelmed by the variety technologies available online today. To effectively choose the appropriate tool one should be aware that the intended instructional outcomes are keys to cultural-educational paradigm shift learning. As mentioned earlier, the author tried several tools that are free and available in the market. The use of Axiomatic Design (AD) process helps identify the right tools with appropriate pedagogy. The AD law simplifies what learning design for engineers are suitable to create a paradigm shift in a rich Papua New Guinea student culture. The process integrates technologies to create synergies in the acquisition of knowledge that will lead the student to have the capacity to assimilate new data and to solve a real problem as they arise; have a skill of designers and innovation drivers who are capable of taking into account the systematic challenges such as sustainability. The Google Classroom plays a vital role in bringing the tools that will enhance students 21st century skills.

Considering the use of Google Classroom in the case of Material Engineering Class in Concrete Technology, a student comment (McGregor Yangu) says,

”As a student and a future engineer, I believe the introduction of wireless education especially Google Classroom is a very good initiative taken by the department to established something like this. Concerning innovation in concrete, the Google Classroom has provided many good sources internet links that help us understand concrete technology to an all-new level.”

Another student (Abel Moke) says “I have learned a lot in innovating concrete via Google Classroom. The electronic lectures notes and documentary movies were uploaded, and they were viewed by students. I observed that it is an effective way to bring new information to students. You can view the notes on campus, out of campus or anywhere in the world. I learned a lot on concrete innovation via Google Classroom and hope that other students learned as well. “

According to another student (Pakea Kevin), “Innovating concrete is very important topic that is covered in this semester. It is a big chapter, and it would have requires a lot of research, practice labs and more to understand all the concepts of this theme. However, for my case, Google classroom was too helpful throughout this semester. It helps me providing the necessary information that is needed to understand fully the theme of CE 222 this 2nd semester of 2016. With the latest updated lecture notes, videos and extra notes found in Google Classroom helped me a lot to know and understand fully the principles and facts of innovating concrete.

The culture-education paradigm shift learning concept aims to lift barrier with cultural divide by assimilating activities such as project based-based learning, inquiry learning, group discussions, cooperative learning, and examination they know about and integrating new technologies to support it to hone student with needed 21st-century skills.

In conclusion, the student readiness can only be better measured when student get the job and employer are happy that they are equipped to face the challenges in the workplace. Therefore, it is recommended to continue the study and include the graduates as respondents to validate the employability of graduates.

4. Future Work

In every study, not all possibilities are answered in one attempt. There are questions raised about the effectiveness of the methods employed, the CEPSL model, to make a culture-educational paradigm shift. Testing for only a semester to one class (although involving three sections: Civil Engineering, Mining Engineering, and Mineral Processing Engineering students) may not be sufficient to test the impact of the CEPSL model. It is recommended that future work is done because technologies also change quickly, and the readiness of the population to the changes must go with it.

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